

QUARTERLY STATUS REPORT No. 4

Period 23 June 1965 - 22 September 1965

DESIGN, DEVELOPMENT, FABRICATION AND INSTALLATION OF  
105-INCH LUNAR AND PLANETARY TELESCOPE AT McDONALD OBSERVATORY

Contract NASr-242

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A. Review of Progress Prior to this Reporting Period

Previous work has resulted in the selection and basic design of a two-pier cross-axis telescope configuration, using oil-pad bearings for the polar axis and roller bearings for the declination axis. The approximately 105-inch fused silica F/4 primary will have a modified Ritchey-Chretien figure, with principal wide-field Cassegrain operating at f/9. The coude focus of about f/30 feeds into a horizontal sub-floor coude room which uses most of the dome diameter more than 75 feet. Fabrication of the primary mirror began early this year, and is making good progress. Other progress has included the beginning of specific optical designs, buildup of staff, and study of site, building and dome problems.

B. Progress during the Period 23 June - 22 September 1965

In this reporting period, the rapid progress of detailed design work made clear where final design decisions were necessary. In particular, these decisions involved trade-offs in several areas, notably those of weights, balances, flexures and bearing loads, of optical field size versus obscuration and diffraction, and of complexity and cost versus flexibility and operating convenience. It was also necessary to develop a philosophy of procedure for obtaining optical and mechanical contractors with demonstrated experience and ability.

An August meeting in Los Angeles with the NASA technical administrator, Dr. William E. Brunk, emphasized questions of speed of project completion and compatibility of the immediate NASA interest in planetary work with the over-all scientific desirability for a telescope of maximum power and versatility not only for present needs but also for developments to be expected during its 30 to 50 years of useful life. The prime focus option was eliminated from consideration as an item to be funded by NASA.

Mr. J. Texereau, optical consultant from the Paris Observatory, was available for seven days during this period, and was instrumental in our selection and planning of details of the Couder method of mounting the primary mirror. Mr. Texereau also assisted in evaluating the capabilities of the very limited number of optical firms with the demonstrated ability to do work of the size and precision necessary for this telescope.

To the best of our knowledge, the major critical design decisions concerning the telescope have now been made, and Charles W. Jones Engineering is in the process of producing final drawings and specifications suitable for soliciting bids for shop drawings and construction.

### C. Specific Progress and Properties of the Design

In slightly greater detail, the principal features of the telescope are now as follows:

#### 1. Optics

Three basic types of optical system are required, to produce respectively a long-focus coude, intermediate focus Cassegrains, and short-focus Newtonians. Configurations have been selected giving approximate factor-of-two steps in focal ratio and angular scale (hence factors of about four in speed), ranging from Newtonian F/4 through Cassegrain f/9 and f/18 to coude f/33. Each of the focal positions has several important uses. The Newtonian encourages fastest photography of faint objects, offers probably the best opportunity for deepest-penetration in faintness, and in particular gives much the largest potential area of well-corrected field. The short (f/9) Cassegrain has the only secondary exactly fitting the coma-free Ritchey-Chretien condition, hence is the only focus giving all-reflecting wide-field ( $\sim 1/2^\circ$ ) images of high quality. Because of the potential importance of this focus for a variety of auxiliary instruments — some of them possibly bulky — three of these focal points, in addition to the conventional one behind the primary, are provided in the form of broken Cassegrain (Nasmyth) positions on the side of the telescope tube, the beam being deflected to these at will by the rotatable first coude flat. Although coma-free, the f/9 field has objectionable astigmatism toward its edges, along with considerable curvature; a simple single-element quartz aspheric corrector should make possible a 1:1 field, having curvature mild enough for even thick photographic plates to be deformed to it. Although the f/9 focus as designed provides a good compromise with conflicting needs for relatively fast exposures, adequate scale, large field, and fine image quality, nevertheless it falls short of being able to deliver the highest resolution attainable by the telescope. This arises because of the still only modest scale at f/9, and because the large central obstruction (reaching a maximum of 48% of diameter, 24% of area when the full-field sky-shield is used) causes significant diffraction into rings even beyond the fifth. Use of a special f/18 Cassegrain mirror reduces the central obstruction to that irreducible minimum produced by the 30-inch central hole in the primary, obscuring only 8% of the area, but in particular significantly improving the central condensation of light in image points. This effect is especially noticeable in the photography of extended objects, where the high-order diffraction rings spread out light from every bright point of the surface, causing a severe washing out of low-contrast detail. The final coude f/ratio of 33 (instead of 30 as originally proposed) resulted from a compromise forced by the design. To

keep the coude flats small enough to be relatively easily handled, and to centrally obstruct as little of the beam as possible, the longest f/ratio was chosen which is still compatible with the approximately 24-inch collimator beam proposed for the coude spectrograph. This has no deleterious effect on the performance of the coude spectrograph itself, and slightly increases the amount and central condensation of light to the coude focus images.

## 2. Tube

The principal optical elements are contained in or attached to a conical steel tube approximately 12 feet in outside diameter and 24 feet long. This closed-tube configuration was chosen both for rigidity and in expectation of obtaining better tube-seeing. Each of the secondary mirrors will be permanently mounted in one of several cages, individually attached to the tube in a manner to allow relatively quick change from one optical mode to another. Five interchangeable cages are designed:

### a. Cassegrain-Coude Cage

This cage, intended for routine operation of maximum versatility, contains both the f/9 Cassegrain secondary and the standard aluminumized f/33 coude secondary. The two mirrors are mounted back-to-back in the cage so that either may be selected by simply rotating the cage end for end, using the dome crane. Normally, the sky baffles would remain installed in this mode. The nightly observing program could use at the coude any desired combination of spectroscopy, photography, and image-tube work, also at the direct or broken Cassegrain any desired combination of wide or narrow field f/9 photography, spectroscopy in the middle to low dispersion range, photometry, polarimetry, infrared work, and perhaps other programs as well.

### b. High Resolution Cassegrain Cage

A quite special cage is required, solely to hold the small f/18 Cassegrain mirror relatively close to the prime focus position. For this configuration to be used most effectively, the baffles must be removed, along with the first coude flat, normally by the day crew. When so set up, the telescope would be used primarily for highest resolution photography, but also for photometry and perhaps spectroscopy of the faintest objects where the 15% light gain could be useful, and in any event for more routine photometry and spectroscopy should the seeing not permit highest quality work.

### c. Large-field Newtonian Cage

Fast photography with the telescope, at least with present materials, requires the relatively short f/ratio produced directly by

the primary mirror. In addition, our optical parameters permit the achievement of an unusually wide prime (Newtonian) field, exceeding  $2^\circ$ . This field is second only to that produced by full Schmidt instruments and has advantages of scale and light-gathering power over even the largest Schmidts. The Newtonian focus also is for us the only one permitting study, alignment, and support adjustment of the primary mirror by itself - very important during installation and on subsequent occasions when checking conditions of the support systems. Access to the Newtonian is difficult, but can probably best be achieved by having the observer ride the telescope in a small chair-cage attached to the side of the full Newtonian secondary cage.

d. Super-reflecting Coude Cage

Two coude secondary mirrors, mounted back-to-back with either being selected by rotating the cage end for end, if technology permits are to be given super-reflecting coatings respectively in UV-green and yellow-IR regions. Operated without sky baffles and with the new choice of coude f/ratio, these would obscure only about 14% of the beam, a gain of 10% over the conventional coude. If at least 10% higher reflectivity over working aluminum coats can be obtained and maintained with the special coatings, then for pure coude work, this cage will permit work on objects several tenths of a magnitude fainter than with the standard cage, or nearly a fourth again as much work on "normal" objects per night. Since fast, high-dispersion, high-resolution coude spectroscopy is a major goal of this telescope, the gains which might be achieved by this cage option should not be ignored.

e. Small-field Newtonian

Whereas the wide-field Newtonian requires a moderately large Newtonian flat and a substantial multiple-element modified Ross corrector, it is possible with a simple quartz aspheric to generate even with the Ritchey-Chretien primary a useably large on-axis Newtonian field of high definition. Because of the smaller central obscuration and the minimum optics, this focus offers the best opportunity for short focal length work (high-speed photography and perhaps high-speed image tube work, also associated photometry and nebular spectroscopy) going down to the faintest objects normally attainable with the telescope using moderate exposures. This cage, although the simplest of all, nevertheless also requires a seating arrangement for the observer.

The total telescope system also requires other mirrors, of course, to bring the beam to the coude. Of these, the tertiary (first coude flat), in the tube at the declination axis, is mounted on a remotely controlled mechanism that folds the mirror out of the Cassegrain beam. In addition, this mechanism is on a bearing so arranged as to allow the mirror to rotate through  $270^\circ$  to produce three positions of folded

Cassegrain focus at the sides of the tube, in addition to the coude beam.

When the telescope is not in use, the primary and tertiary mirrors are protected by a hinged-flap cover system located inside the telescope tube.

The quarternary (second coude flat) located in the polar axis, is designed as a relatively thick (10-inch) mirror both sides of which are to be figured as flats. One (or perhaps both) will be given super-reflecting coatings; the mirror, on a motor-driven pivot with front-surface defining points, can be rotated at will by the observer to select the most efficiently reflecting face for his work.

Still a third coude flat is required below the end of the polar axis to fold the beam back into the sub-floor coude room. However, this flat is only a few inches in size, and will really be many flats on a turret, each coated for near 100% reflectivity in a wavelength range of interest.

### 3. Mounting

The telescope utilizes the cross axis (English) mounting, desirable especially because of the large clear convenient Cassegrain focus and the simple basic four-mirror coude. The telescope tube is connected to the polar axis structure by a pair of very large ball bearings, mechanically the most critical point of the design. A separate design study has confirmed C. W. Jones Engineering's statement that the probability of bearing failure can be reduced almost arbitrarily close to zero, and that smoothness of motion of one or two tenths of an arc-sec should be present.

The polar axis structure rotates on four oil-pad bearings, two each on the north and south ends of the polar axis. In addition, the north pier carries the thrust load by means of a longitudinal oil pad. Drive, worm, and worm wheel, for convenience of access and service, are unconventionally located at the upper end of the polar axis, on top of the north pier. Telescope balance is achieved by built-in counterweights, by manually installable trim counterweights, and by roughly a ton each of motor-driven counterweights in declination and in right ascension, with accurate positioning dials.

The two piers are constructed of reinforced concrete and are isolated from the building. The horizontal coude spectrograph frame is mounted directly to the two telescope piers, to obtain and hold proper alignment of the spectrograph with the coude beam.

### 4. Drive and Control

The 105-inch telescope right ascension drive mechanism is to be specified as a standard gear reduction design feeding into the drive worm, as with most of the recently built telescopes, with the exception that the position indicators and the control unit electrical inputs will probably

be digital devices. However, a flexibility of correction to the drive worm is to be provided, so that the builder may originally, or we may later, substitute a torque motor or even some other system should the advantages become convincing. A similar system in declination has slightly lower performance specifications but higher power requirements because of the bearing friction to be overcome.

## 5. Drawings

The above features, and many other details, are indicated on the most recent general assembly layout drawing (Jones Print C660E200) and the newly-revised 76-foot dome elevation and floor plan drawing (Texas Print 26010) attached in reduced scale at the end of this report.

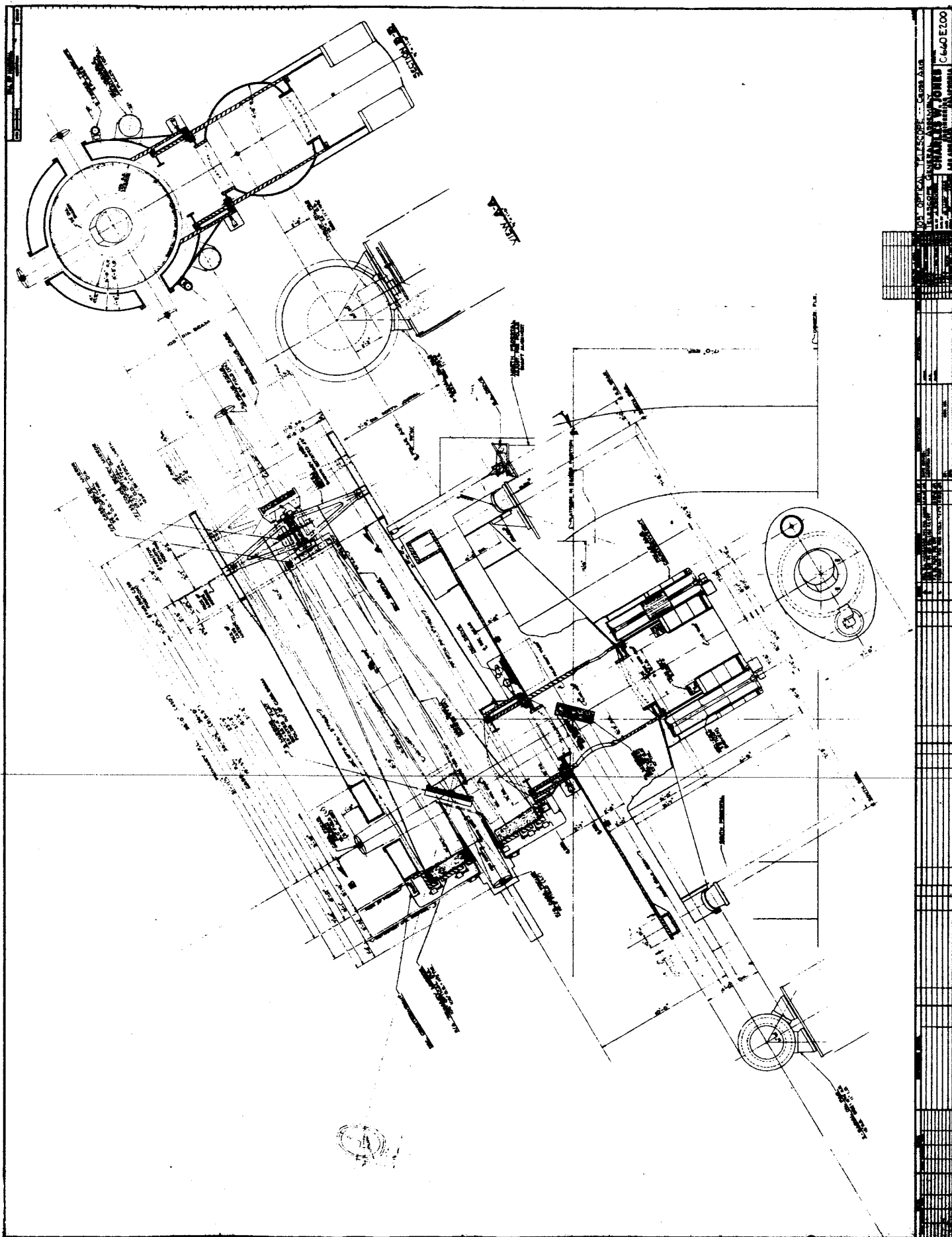
## D. Personnel Connected with the Contract

During this reporting period, part-time or full-time employees under the contract included:

Dr. Andrew T. Young (instrumentation design, part-time)  
 Jean Texereau (optical consultant, part-time)  
 Charles L. Seeger (engineering and electronics)  
 Professor C. G. Wynne (optical design consultant, part-time)  
 Professor Henry Grady Rylander (bearing engineering consultant, part-time)  
 Johnny E. Floyd (mechanical design, part time)  
 Charles Jenkins (project administration)  
 Charles D. Thompson (engineering and drafting)  
 Marion L. Davis (electronics)  
 Jack Sedwick (layout and drafting)  
 Lee Wilson (mechanical design)  
 John F. Blanton (mechanical design and drafting)  
 James R. McCullough (computing)  
 Kelly Anne Wightman (drafting)  
 Phyllis Kirkpatrick (secretary)  
 Margaret Smith (secretary, part-time)  
 Ina Harrison (secretary, replacing Mrs. Smith)

## E. Financial Report

NASA Form 1030 (2-64) for this contract is submitted quarterly by the Auditor's Office of The University of Texas.



CHARLES W. JONES  
C-4402100



